artment of Agriculture Agricultural Research Service November 1991

Agricultural Research

BEEF
The first in a 3-part series

Beef—Conception to Consumption

Cattle and ranching are more than just players in the romantic drama of America's Old West: They're big business.

According to U.S. Department of Agriculture figures, sales of cattle and calves totaled about $40 billion in 1990—24 percent of all U.S. farm marketings that year. That makes the cattle industry the largest segment of the Nation's agricultural economy.

The connection between cattle and money is nothing new. The Roman word for money, *pecunia,* reflected in our modern adjective impecunious, came from the Latin *pecus,* meaning cattle. And some of the earliest known coins are adorned with an ox head, suggesting a link between wealth and cattle ownership.

Today, the beef business is booming as cattle producers move more meat to market. Production in 1991 is anticipated to hit 22.9 billion pounds, 1 percent higher than last year.

More than 1 million farm and ranch operations raise 100 million beef cattle on pastures and in feedlots each year. Thus, this industry is a vital part of our food production system and of the rural economy of this country.

Foods of animal origin supply about 70 percent of the protein, 35 percent of the energy, 80 percent of the calcium, 60 percent of the phosphorus, and important quantities of the B vitamins and trace minerals in the average American's diet. Beef is one of the primary contributors.

It is estimated that 80 percent of the nutrients in the lifetime diet of the beef animal—grass, hay, silage, and crop residue—cannot be digested and used by humans for nutrition.

Of the remaining 20 percent, beef cattle are fed primarily feed grains such as sorghum and corn rather than food grains such as wheat and rice that can be used for human consumption.

Thus, beef production efficiently converts otherwise predominantly unusable natural resources into a nutrient-laden, desirable product.

Since beef cattle are raised in all 50 states, the beef industry at a local level must contend with a vast array of weather extremes, feedstuffs, and suitable breed types.

Therefore, to be the most efficient, research must be conducted in different geographic regions to fine-tune the findings to the needs of the farmers and ranchers of that area. It is the duty of researchers to identify the most effective combinations of all factors that will improve the efficiency of production and provide an adequate and safe supply of meat and meat products for consumers.

At the same time, a coordinated national plan is needed, with appropriate input from industry regarding research priorities to be on target and have a quick and effective impact on the broad array of beef industry needs.

The lifestyles and eating habits of the public have changed dramatically in the past decade. Those concerned with the amount of fat in their diet are demanding and receiving a leaner beef product with improved quality and consistency.

Consequently, research is required to provide new technology on the processing, quality, and safety of the end product in human diets.

The Agricultural Research Service has an excellent research program in place to assist producers and consumers of beef. More than 200 projects at 34 locations across the United States are producing research information in the agency's nationwide program.

The program varies from cutting-edge basic genome mapping research to applied research, with each project aimed at solving a specific problem. About $34 million is appropriated by Congress annually to support the 140 scientists in this ongoing program.

Robert R. Oltjen
Associate Deputy Administrator
for Animal Sciences
Agricultural Research Service

Agricultural Research

Cover: An Agricultural Research Service herd on the move near Miles City, Montana. Photo by Jack Dykinga. (K-3908-5)

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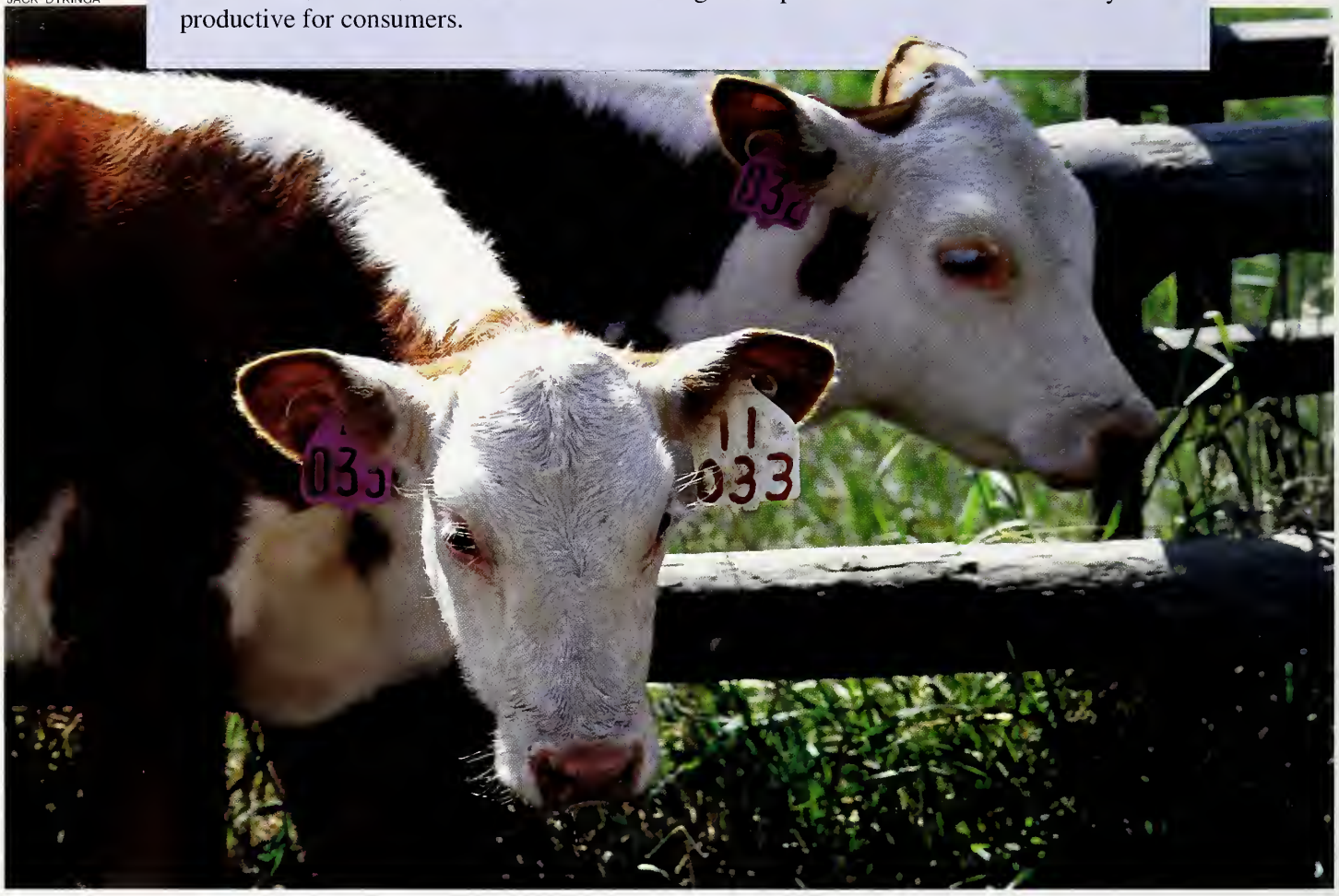
Robert W. Norton, Director
Information Staff

Agricultural Research begins a 3-part series on beef cattle, with production research featured in this issue. In December, we cover research on cattle diseases. In January, it's safety and diet/health studies. However, the information contained in these issues is just a sampling of the more than 200 projects under way. From Pullman, Washington, to Brooksville, Florida, ARS scientists are working to keep America's cattle herd healthy and productive for consumers.

JACK DYKINGA



Hereford twins produced at the ARS Range and Livestock Research Unit at Miles City, Montana. (K-4323-18)

Good Breeding

From Simple Beginnings to Genetic Engineering

Since the days when mankind first became a herder of animals, the genes of livestock have been rearranged by selective breeding within the herd for desired traits.

From those simple beginnings has grown the modern science of genetics, with a dazzling array of tools to help livestock producers in their selections.

"We now have the expertise to improve the reproductive efficiency of our farm animals and improve existing breeds through the direct transfer of genes from other animal species," notes Harold W. Hawk, an animal physiologist with the Agricultural Research Service's Gene Evaluation and Mapping Laboratory at Beltsville, Maryland.

Such switching or engineering of genes offers a host of benefits: more efficient utilization of feed by farm animals, faster growth, greater resistance to disease, even the ability to produce pharmaceutical products in the milk of dairy animals.

In one project at the Beltsville laboratory, scientists are studying ways to improve the survival rates of cow embryos incubated outside the natural mother for about a week, then placed in a surrogate mother for gestation.

"We have been able to increase fertilization rates of cow eggs from 60 percent to as much as 100 percent and have improved the survival of the embryo from 10 percent to 20 percent," says Hawk. "In essence, we're setting the stage for the efficient genetic engineering of cattle."

However, much of the laboratory's work is done on species other than cattle because, Hawk explains, "cows are expensive to maintain, they reproduce slowly, and they have, at best, two offspring per pregnancy."

By contrast, hogs can produce two litters per year, averaging about 10 piglets per litter.

"And many of the techniques that we learn from our research on pigs and sheep can eventually be used to produce transgenic cattle," he adds.

One such technique is the transfer of a gene or gene replica into a newly fertilized egg.

Within a few hours after fertilization, the genetic material of the sperm and egg are naturally enclosed in membranes within the egg. These bodies are called the pronuclei. It is at this stage, before the pronuclei unite to form an embryo, that gene transfer usually takes place.

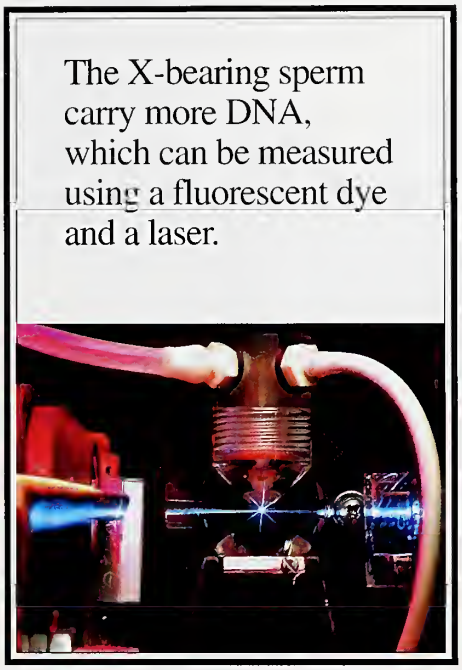
To accomplish this, the egg is held by gentle suction from a glass tube. While looking through a microscope, the scientist uses a micromanipulator to maneuver a fine glass needle containing copies of the new gene. The egg membranes and membrane of one pronucleus are pierced, and the gene replicas are placed inside the pronucleus.

Embryos of pigs and sheep are then placed immediately into a surrogate mother, but cow eggs are incubated for 7 to 8 days before transfer. A small percentage of these embryos will grow into offspring in which the new gene is "expressed" or working.

Farmers have long dreamed of being able to select in advance the sex of the offspring of their livestock. Generally, beef producers would prefer more males, because steers grow faster than females.

"We are getting closer to that goal," says Lawrence A. Johnson who is at the Germplasm and Gamete Physiology Laboratory at Beltsville. "In the future, sex preselection will be a common facet of livestock production."

SCOTT BAUER



(K-4288-12)

Johnson has developed a system for sorting batches of sperm cells based on the amount of DNA they carry.

"Sperm cells carrying the Y chromosome produce males, while sperm carrying the X chromosome produce females," explains Johnson. "The X-bearing sperm carry more DNA, which can be measured using a fluorescent dye and a laser."

The sperm cells are first treated with a fluorescent dye, then passed into a cell sorter, where they flow single-file past a laser beam. The X sperm give off more fluorescent light than Y sperm because of their greater DNA content. Based on the light they emit, the X and Y sperm are collected in separate tubes.

"To date, we have achieved live births with artificial insemination of sorted X and Y sperm of pigs and rabbits," notes Johnson. "At least 75 percent of the offspring have been of the predicted sex."

The same principle would apply in sorting cattle and sheep sperm. However, the cell-sorting procedure can currently sort only about 2 million sperm a day, while 10 to 15 million sperm are needed for conventional artificial insemination of a cow.

An alternative procedure to the use of millions of sperm—fertilization of cow eggs outside the uterus—would drastically reduce the number of sperm needed.

"We are also trying to identify some sort of sex-specific marker on the surface of the sperm," says Johnson. "If we are successful, we may be able to develop a batch procedure to be used in preselecting populations of male versus female sperm and thus make the procedure practical."

Body Fat Affects Puberty

Just as the health and diet of a human mother-to-be can affect her unborn child, nutrition and body condition play a crucial role in producing a calf, says animal scientist Andrew C. Hammond.

Hammond, research leader at the ARS Subtropical Agricultural Research Station at Brooksville, Florida, is working with reproductive physiologist Chad C. Chase, Jr., on how body fat figures into when a heifer reaches puberty and can be bred.

"Puberty is important because one of our biggest problems is reproductive efficiency," Hammond says. "The cattle necessary for a subtropical environment such as we have here in Florida are typically older at puberty and have a longer gestation."

ROB FLYNN

Using compounds in blood samples from heifers, animal scientist Andrew Hammond monitors nutritional status as related to body composition and puberty. (K-4346-2)

Cattle of the *Bos indicus* type, as typified by the Brahman breed, are better equipped by nature to survive sultry temperatures. But 4 years of data from Brooksville show the average age of Brahman heifers at puberty is about 602 days, compared with 503 days for Angus heifers, a *Bos taurus* animal.

Additionally, Brahman cows have a mean gestation length of 293 days, compared with the Angus' 278 days.

"A longer gestation period means the cattle producer has a shorter amount of time in the calendar year in which to get that cow bred again," notes Hammond. "A certain amount of time has to pass after calving before a cow comes back into heat.

"We know that a cow needs to be in a certain body condition to rebreed," he points out. "Quite a bit of work has already been completed on characterizing age and body weight at puberty; we're interested in the heifer's body fat."

To this end, Hammond and colleagues at Brooksville began a 3-year study in the fall of 1990 involving heifers of the Hereford, Senepol, Angus, and Brahman breeds, plus crossbred heifers from Hereford and Senepol parents.

Once the animals are weaned, they're put on one of two diets offering different energy levels. The heifers are then bred to Angus bulls under careful supervision so researchers can note the female's body composition at the time she conceives.

"The practical aspect of all of this is refinement of feeding," says Hammond. "We're trying to determine differences in cattle types and how you might have to feed various types for optimum reproductive performance."

Animal physiologist Robert B. Staigmiller is quick to second the idea of the importance of good nutrition in reproduction.

"You can probably change the age at which the animal reaches puberty by as much as 8 weeks with the right nutritional program," says Staigmiller, who is based at the ARS Range and Livestock Research Unit at Miles City, Montana.

"Nutritional needs are different for different biological types of animals. You need to know your breed characteristics."

But reaching puberty doesn't always equate with immediate pregnancy, he adds.

"We've found that heifers bred on their third estrus cycle have a 21 percent greater conception rate than heifers bred right at puberty," Staigmiller notes.

"We've reasoned there are at least two possible causes for this. Maybe that first egg produced doesn't have as strong a possibility of becoming an embryo.

"The first egg ovulated will not have been exposed to all the hormonal signals of a regular estrus cycle like eggs ovulated later. Or perhaps the uterine environment isn't quite right in a heifer at puberty."

To test this theory of egg viability, Staigmiller and coworkers are taking eggs produced by mature cows and transferring them into heifers at the young females' first or third estrus cycles. Staigmiller says another year of data is needed before the results can be evaluated.

On the question of uterine environment, "We know the tissues of the oviducts and uterus undergo dramatic changes at puberty," says Staigmiller. "These changes may not be completed during the first estrus. This could have an adverse effect on the ability of fertilization to occur, or it could be detrimental to the early life of the embryo.

"Overall, what we've seen so far tells us that it's not sufficient to barely have a heifer at puberty at breeding time," Staigmiller concludes. "A young female's chance of becoming pregnant early is greater if she has reached puberty in time to have two or three estrus cycles before the start of the breeding season."

Twinning Project

A small percentage of the time—about 1 percent for Hereford and Angus to 4 percent for Holsteins—the producer is rewarded with twin calves. According to Keith E. Gregory, an animal geneticist at the Roman L. Hruska U.S. Meat Animal Research Center (MARC) at Clay Center, Nebraska, it is possible to improve those odds—possible, but not simple.

"We've had a research project on twinning in beef cattle since 1981," says Gregory. "Research has shown that for intensive production systems, twinning has the potential to increase efficiency of beef production by 25 to 30 percent."

Gregory and colleagues at Clay Center began the twinning project with carefully selected foundation females that had naturally produced twins at a high frequency. Their daughters in turn twinned at a rate of about 9 percent. Later, these daughters were fertilized with semen of bulls from Sweden or Norway whose daughters had produced twins at a frequency of about 10 percent.

In their search for sires to use in boosting twinning rates, the scientists consider ovulation rate, determined by rectal palpation, on seven daughters of each young sire for seven estrus cycles. This information not only enables the researchers to pinpoint the best sires, but also helps them select replacement females.

"The twinning frequency since this procedure began has been increasing at about 2 percent a year for the last 5 years," Gregory notes. "In the spring of 1991, it was 23 percent."

But such victories don't come easily, Gregory adds.

"Increasing twinning in a herd has a very high input requirement in terms of management," he emphasizes. "And we think that for it to be really economically viable for a producer, a twinning rate in the range of 40 to 45 percent is necessary.

"Based on the progress to date, we're of the opinion we can achieve that. But we think that superior breeding stock is an essential part of a twinning technology package."

Twins can be a mixed blessing, Gregory warns. "Death loss of twin calves is higher, and we're finding that a cow that's had twins has a longer interval before she can be bred again," he says.

"That's because her body cavity is so full of fetuses that there literally isn't room for her to eat enough of a normal low-energy beef cow diet to maintain herself in good enough condition to rebreed. So you must have these cows on a higher energy diet in their last trimester of pregnancy."

According to Sherrill E. Echternkamp, an animal physiologist at Clay Center, the increased energy requirement and the need for more assistance in calving make it vital that the producer know which cows are carrying twins.

"In twins, there's fairly high calving difficulty," he notes. "They get tangled up together. About 35 percent of twin births require assistance, compared with about 15-20 percent of single births."

For that reason, the Clay Center scientists are increasing their use of ultrasound diagnosis to determine the fetal number, Echternkamp says.

"We're about 85 percent accurate when we evaluate the cows 45 to 85 days after breeding," he says. "Since we've started doing that, we've increased calf survival about 10 percent."

KEITH WELLER

Animal scientist Calvin Ferrell analyzes a blood derivative to estimate the uterine blood flow in pregnant cows. Blood flow may be a factor in fetal weight gain. (K-4326-2)

Uterine Blood Flow

In one of the more curious twists of science, Clay Center researcher Calvin L. Ferrell has shown that the uterus itself is much more than just "rented space" for the developing calf.

In a study begun in 1989, purebred Charolais and Brahman cows were injected with hormones to increase the number of eggs they produced. The eggs were fertilized by artificial insemination with semen from purebred Charolais or Brahman bulls.

Then Ferrell and coworkers implanted the purebred Brahman embryos in Charolais cows, and the purebred Charolais embryos in Brahman mothers. Some of the fetuses were recovered for study at 230 days of gestation and others at 270 days.

"At 230 days, the cow hadn't had any influence on calf growth," says

KEITH WELLER

Animal geneticist Keith Gregory (left) and cattle operations manager Gordon Hays discuss care of heifers specially selected for their likelihood of producing twin calves. (K-4320-9)

Ferrell. "The Charolais calves, regardless of which breed of mother they were in, were nearly twice the weight of the Brahmans—23 kilograms versus 13 kilograms.

"But at 270 days, the Charolais calves that had been inside Charolais mothers weighed about 13 kilograms more than the Charolais calves inside Brahman mothers. And the Brahman calves inside Charolais mothers weighed about 5 kilograms more than the Brahmans inside Brahmans."

Ferrell contends that uterine blood flow may be contributing to the difference. By monitoring the mothers' blood flow to the fetuses through the use of markers infused through catheters in the mothers' veins, the researchers discovered a much lower uterine blood flow in the Brahman cows.

"Also, the placental tissue is smaller in the Brahman—apparently a common trait in *Bos indicus* cattle," says Ferrell. "That smaller tissue is just not adequate to supply all the nutrients a larger fetus needs.

"If we could control uterine blood flow, we might be able to restrict or improve fetal growth. Presumably uterine blood flow is a genetically controlled trait. If we could find the genes, we might be able to modify or use them as a selection tool."

Bigger calves can translate to more calving difficulty, a hot topic with ARS reproductive physiologist Robert A. Bellows at Miles City, Montana.

"I've been working on causes of calving difficulty, called dystocia, since 1962," says Bellows. "I'd estimate this one problem results in an income loss of more than $800 million annually to U.S. cattle producers."

One common cause of dystocia is a calf that's too big to go through the mother's birth canal. Another problem is abnormal hormone changes in the dam just before calving.

The scientists have noted a difference in precalving levels of the hormones estrogen and progesterone in cows with calving difficulty. These and other hormones play a role in the strength of the cow's contractions and in preparing the birth canal for delivery of the calf, says Bellows.

The stakes are higher than just one calf one year, Bellows adds.

"Cows in labor for long periods of time have poor reproductive performance in the subsequent breeding season, resulting in a reduced or delayed calf crop the next year," he points out.

Cutting back on the pregnant cow's nutrition to try to trim calf size isn't effective, Bellows says.

"We weren't able to accomplish that, but the reduced nutrition did result in poor rebreeding of the cow," he says. "And cutting calf size too much, no matter how you do it, can backfire because very light calves don't gain weight as rapidly or weigh as much at weaning."

Current studies with five breeds of cattle have uncovered differences in the degree to which the mothers will let the calves' genetic potential develop in the uterus.

In the study, Charolais and Shorthorn cows produced the heaviest calves, regardless of whether the sire was a high- or moderate-growth animal, says Bellows. At the other end of the spectrum, Brahman dams repressed fetal growth rate to a certain extent.

Jersey cows, by contrast, produced low-birth-weight calves from low-growth sires and high-birth-weight calves from high-growth sires. Calves from Longhorn mothers were medium-size, regardless of the sire's growth rate.—By **Sandy Miller Hays** and **Vince Mazzola,** ARS.

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JACK DYKINGA

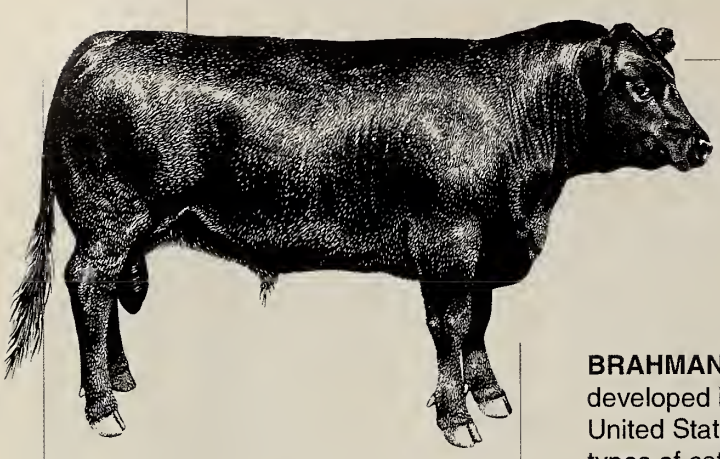
Animal physiologist Robert Bellows observes body condition in different breeds on irrigated pasture. Body condition affects rebreeding performance. (K-4322-9)

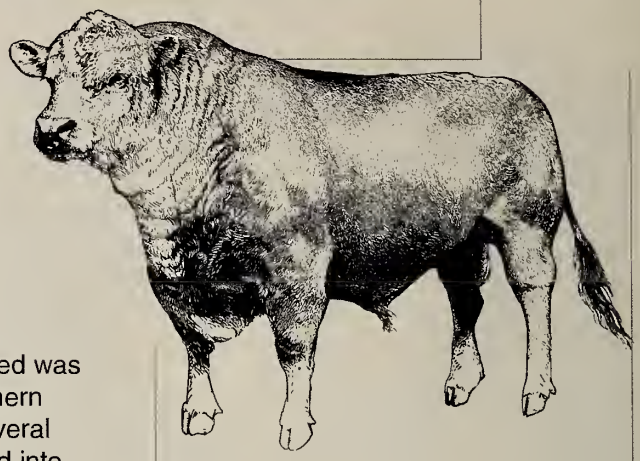
JACK DYKINGA

Using an ultrasound scanner, animal physiologist Robert Staigmiller examines heifer's ovaries at puberty. (K-4322-20)

A FEW EXAMPLES OF

TYPICAL MODERN BEEF CATTLE

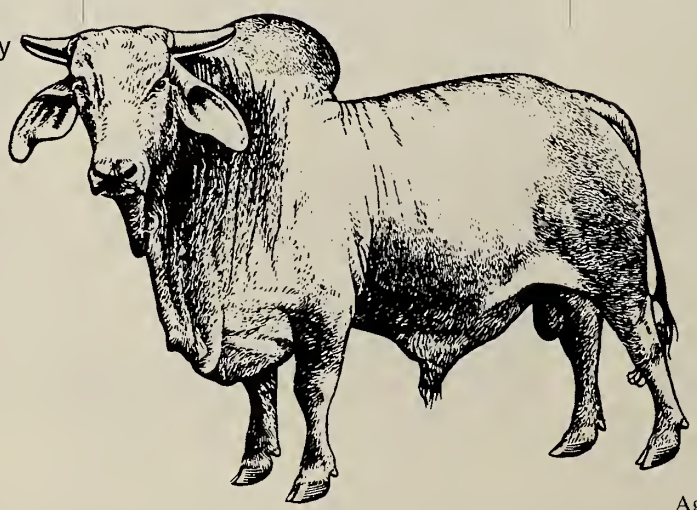




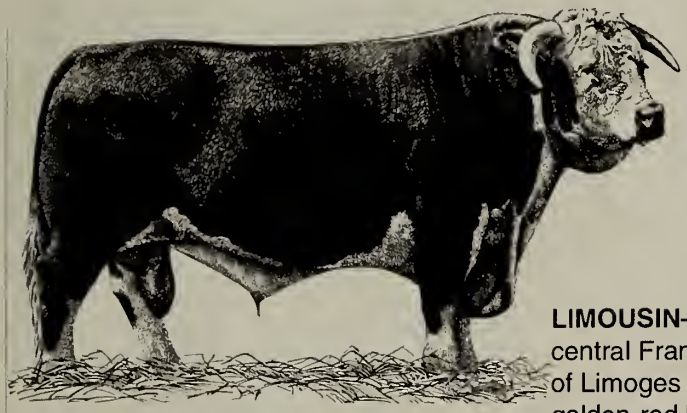
ANGUS—This breed originated in Scotland from the black cattle native to the northeastern counties of Aberdeen, Angus, Kincardine, and Forfar. The breed is thought by some to have descended from an earlier black, horned breed in Scotland, while others argue that the breed's family line stretches back to the polled (hornless) cattle of Britain. The Angus breed made its debut in the United States in 1873 when a retired London silk merchant-turned-cattleman in Victoria, Kansas, imported four bulls for use in crossbreeding with Longhorn cattle. Angus cattle typically have a black or dark red, smooth hair coat and no horns. An Angus bull weighs between 1,800 and 2,200 pounds; a cow is likely to attain between 1,100 and 1,300 pounds.

BRAHMAN—This breed was developed in the southern United States from several types of cattle imported into the United States between 1854 and 1926. Contributing to the genetics of the American Brahman are the Gyr, Guzerat, Krishna Valley, and Nellore breeds of humped cattle found in India. Brahmans are noted for their humped back, long, drooping ears, and loose skin. Many Brahmans are light to medium grey in color, but the coat color can range from red to almost black. Brahman bulls weigh in at 1,600 to 2,200 pounds while cows in average condition range 1,000 to 1,400 pounds.

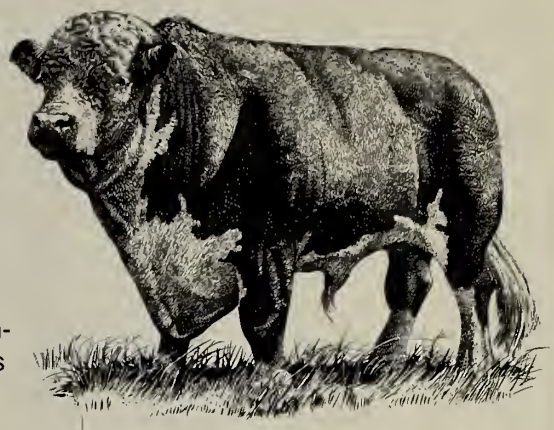
CHAROLAIS—Native to the district around Charolles in central France, Charolais is one of the oldest of several breeds of French cattle. Charolais came to the United States by way of Mexico. After World War I, a young industrialist obtained two Charolais bulls and 10 heifers for his ranch in Mexico. A Kyle, Texas, cattle producer saw the breed there, and, in 1934, received two bulls as a gift from the Mexican secretary of agriculture. Charolais are usually a white or very light straw-color, with pink skin and mucous membranes. A Charolais bull typically weighs 2,000 to 2,400 pounds and a cow weighs 1,300 to 1,700 pounds.



In many U.S. beef herds, you're likely to see a mixture of breed lines. American cattle ranchers today are drawing on the genetics of an estimated 50 beef breeds; what follows are just a handful of the lines commonly seen in production in this country.

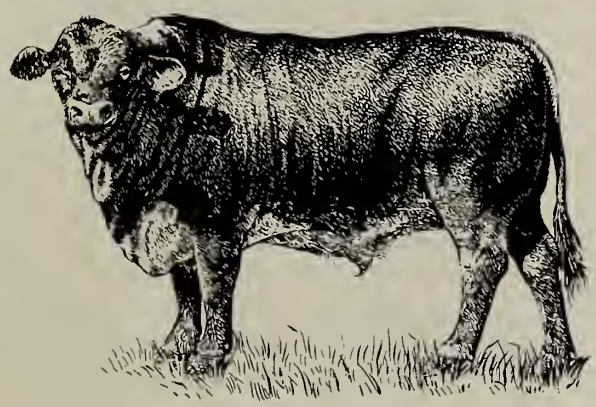


HEREFORD—Founded in the 1700's by farmers near Herefordshire in the County of Hereford, England, this breed came to the United States in 1817 when famed Kentucky statesman Henry Clay added a Hereford bull and two females to his herd. The first Hereford breeding herd in America is considered to be one established in 1840 at Albany, New York. Large numbers of Herefords were imported in the 1870's. Herefords have red bodies and a distinctive white face, as well as white markings on their chest. Other characteristics are a thick hair coat and medium-sized, down-turned horns. Hereford bulls weigh on average 2,300 to 2,400 pounds; cows average 1,100 to 1,500 pounds.



LIMOUSIN—Native to south-central France in the regions of Limoges and Marche, the golden-red Limousin are described in French farm records dating back to the 1600's. It has been suggested that the distinctive 7,000-year-old cattle drawings in the ancient Lascaux cave dwellings near Montignac, France, identify the Limousin as one of the most direct descendants of the original prehistoric cattle, *Bos primogenesis*. The importation of a bull named Prince Pompadour into Canada in 1937 paved the way for the shipment of bulls to the United States 3 years later. Limousin cattle may have medium-size, forward-turned horns. Limousin bulls range from 1,900 to 2,400 pounds, while the cows weigh about 1,100 to 1,300 pounds.

SIMMENTAL—Home for this breed is the Simme Valley of Switzerland where they developed during the Middle Ages and subsequently spread to Italy, Germany, Austria, and France. Simmental cattle characteristically have white to light-straw-colored faces and red or dark red bodies, with white or cream-colored underbellies, legs, and feet. The first Simmentals came to the United States from Canada in 1969. The breed is established all over the world, including South Africa, South America, and the Middle East. Simmental bulls weigh 2,200 to 2,800 pounds and cows weigh 1,100 to 1,500 pounds.



DOUG WILSON

How Now, Beef Cow?

Research cattle near Miles City, Montana. (K-1216-14)

In the beginning, there were Longhorns, and they were tough. Tough in more ways than one: Able to fend for themselves in the wild, equipped as they were by nature with dual daggers, and sinewy enough to survive the dusty treks between distant water holes on the American range.

Described by one observer as "meatless, milkless, and murderous," these hooved ghosts from the days of Spanish conquistadors nonetheless provided the foundation for the infant U.S. commercial cattle industry's first exploration of the joys of heterosis.

Known more simply as hybrid vigor, heterosis is the biological phenomenon that allows crossbred offspring to outperform the average of their parents. As 19th-century American consumers began seeking steaks that could be politely chewed rather than gnawed, the rugged Longhorns were crossbred with stylish Shorthorn cattle from Scotland.

To this genetic marriage, the Shorthorns brought overall improvements in mothering ability, weaning weights of calves, and herd disposition as well as quality of beef. The Longhorns in turn bestowed their legendary hardiness.

Far from satisfying once and for all the demands of the American cattle rancher, the Shorthorn/Longhorn combination of the 1800's simply took the first step on a long and continuous road to customized cattle. The merits of various breeds—or combinations of breeds—are still a hot question among cattle producers and researchers alike.

At the Roman L. Hruska U.S. Meat Animal Research Center in Clay Center, Nebraska, animal scientist Larry V. Cundiff has spent two decades evaluating a veritable rainbow of beef breeds, from the familiar dark Angus to the white-tailed Pinzgauer.

"MARC actually began these evaluations in 1969," notes Cundiff. "There was an obvious opportunity, in that all sorts of new breeds were being introduced in the United States—Limousin from France, Simmental from Switzerland—and we had a new facility with the land and feed production capability needed to evaluate them."

The merits of various breeds—or combinations of breeds—are still a hot question among cattle producers and researchers alike.

Using either Hereford or Angus females, the two dominant beef breeds in the United States in 1960, Cundiff and others with USDA's Agricultural Research Service have evaluated more than two dozen different breeds of sires hailing from Europe, Africa, India, and South America.

The program focused first on crosses with Jersey, South Devon, Limousin, Charolais, and Simmental sires in Cycle I, from 1970 to 1972, and Red Poll, Brown Swiss, Gelbvieh, Maine Anjou, and Chianina sires in Cycle II from 1973 to 1974.

Cycle III, in 1975 to 1976, saw calves from Hereford or Angus mothers and Brahman, Sahiwal, Pinzgauer, or Tarentaise sires. Cycle IV, 1986 to 1990, featured Salers and Charolais sires from France, Galloways from Scotland, Nellores from South America, Piedmontese from Italy, Gelbvieh from Germany, and Pinzgauer from Austria, as well as the old standbys, Longhorns and Shorthorns.

Cycle V, begun last June, used semen from the Tuli and Boran from Africa, the Caracu from Brazil, the Belgium Blue from Belgium, and a repeat round with the Italian Piedmontese.

Each cycle also included purebred Herefords, purebred Angus, and Hereford/Angus crossbreeds. In addition, the female crossbred offspring from the various matings have been bred to Brahman, Devon, Holstein, Santa Gertrudis, or Brangus sires.

"In each sample, we tried to evaluate a large number of biological types, depending on the availability of sires," Cundiff explains. "We like to use 20 to 25 sires per breed."

One conspicuous distinction: *Bos indicus,* including the humped cattle common to tropical countries, is generally slower to mature than *Bos taurus,* which includes the domestic breeds common to the temperate zones such as England and continental Europe.

"Here at MARC, the *Bos indicus* breeds we've evaluated include Nellore, Brahman, and Sahiwal," says Cundiff. "They're very slow to reach puberty. This can be a problem if you want your females to calve as 2 year olds."

Grouping the breeds by biological type on the basis of growth rate and mature size, lean-to-fat ratio, age at puberty, and milk production, Cundiff has uncovered some other noteworthy differences.

For example, retail product weight of beef at 458 days of age has hovered at 410-420 pounds for the Red Poll-Devon-Hereford/Angus group, compared with 470-500 pounds for the Limousin-Charolais-Chianina group.

But on the question of marbling—the interwoven fat generally associated

with tenderness—the Limousin-Charolais-Chianina group scored lowest.

Leading in marbling scores was the relatively diminutive Jersey and the Devon-Red Poll-Hereford/Angus grouping, with scores above 11, compared with 8.3 for Chianina and 9 for Limousin.

"Among breeds, there's a great opportunity to produce cattle to provide two types of beef," says Cundiff.

"On the one hand, you can grow beef that's low in fat and caloric content and more suited to the customer who wants to limit intake of saturated fats.

"But you can also grow highly marbled beef that's well suited to the gourmet food trade. The genetic diversity out there offers all kinds of options."

When cattle producers select their herd's breed, marbling may not be the only thing on their mind. For example, if home for the herd means wide open spaces, the producer, who might not always be on hand to personally usher the cows through the rigors of birthing, may need a breed that's long on calving ease.

In Cundiff's Cycle IV-heifers born 1986-87, the Nellores—a *Bos indicus* breed—ranked last against heifers from nine other breeds in reaching puberty, hitting the mark at 402 days of age, nearly 7 weeks after the Piedmontese.

But the Nellore breed chalked up better than 95 percent unassisted calvings for Cycle IV calves born 1988-89, well ahead of the 86 percent of their nearest competitor, the self-sufficient Longhorns.

Close attention to attributes other than growing the perfect steak is nothing new to American cattle owners, Cundiff adds.

"Cattle have been raised primarily for beef just in the last 100 years, after the coming of refrigeration," he points out. "Before that time, they were used for milk as draft animals. The Chianina in Italy was a draft breed, as were the Limousin and Charolais in France."

ROB FLYNN

A Romosinuano calf with its Brahman surrogate mother. The calf was imported from Costa Rica as a frozen embryo. (K-4344-1)

Once meat became the objective, the benefits of crossbreeding quickly became evident.

"When the cattle producers of the 1800's introduced the Shorthorns and then the Herefords, another British breed, the first thing they noticed was that the crossbred steers would get fat enough to slaughter a year earlier than the old Longhorn steers did," he says.

"We now know the producers were getting the benefits of hybrid vigor. The purebred Shorthorns or Herefords wouldn't have done as well on their own, although they would have done better than the pure Longhorns." Today's steers are finished in feedlots and ready for slaughter at 14 to 20 months of age, compared with the 48 months of the old-style Longhorns or the 24 to 36 months of the pure British breeds.

As the cattle business modernized and moved into the 20th century, changes in production practices stimulated demand for still more germplasm from across the Atlantic.

"We shifted from a forage diet that was high-fiber and low-calorie to a feed concentrate diet that was high-calorie," Cundiff says. "That high-calorie diet made the British breeds and their crosses too fat.

"That was the primary thing that sparked interest in the continental breeds, starting with the Charolais in the early 1900's. Those continental breeds weren't very popular until we got to the point of concern about overly fat cattle."

Today, matching cattle to production systems and the environment is still a major concern. For example, at the ARS South Central Family Farm Research Center at Booneville, Arkansas, studies have been under way since 1986 to determine different breeds' adaptability to conditions in the sultry South.

"Brahman and Angus are the major breeds we've compared," says Michael A. Brown, research leader at the Booneville facility. "Angus are quite prevalent in the upland hill-type agriculture of this area, and Brahman have some qualities we need. Also, with these two you are assured genetic differences."

A key consideration is the animals' ability to thrive on the upper Mid-South's ubiquitous fescue. Although widely used, this forage often contains a natural toxin that results from a commonplace infection of fescue by a fungus or endophyte.

This toxin can wreak havoc with a cow's body temperature regulation and circulatory system, resulting in poor growth and reproduction as well as the loss of ears, tail switches, or even feet.

"In some respects, Brahmans are more adaptable because of their insensitivity to the taste of fescue," Brown says. "Fescue is not very palatable, but Brahmans seem to eat more of it than other breeds will.

"At the same time, this means they're taking in more of the toxin. But the Brahman has sweat glands that other breeds don't have, and this lets them better dissipate body heat. So even though the toxin shuts down the outside blood supply to their skin, ears, and tail, they have a better way to cool themselves."

DAVID NANCE

At the ARS South Central Family Farms Research Station in Booneville, Arkansas, animal scientists Michael Brown (left) and Wesley Jackson discuss the condition of bermudagrass pasture. (K-4338-1)

Brown says studies have shown animals with Angus parentage that are grazing fescue have higher levels of serum amylase in their blood, indicating the possibility of pancreatitis in those animals.

"Generally, pancreatitis will affect growth and reproduction of the animal," he says. "Also, it's not unreasonable to assume this would be associated with chronic gastric pain, which would reduce the animal's forage intake.

"But we don't see this problem in animals of Angus parentage grazing on bermudagrass. Nor do we see it in purebred Brahmans grazing either forage. And in other studies, with Lance M. Tharel here at Booneville, we've found the advantage of the Brahmans in summer grazing was even greater on the higher-quality bermudagrass cultivars."

While fescue can take its toll on an animal's body, happily it's just as hard on populations of the flies that are notorious cattle pests, says Brown.

"We think that on fescue pastures, the toxin goes through the cow's system and ends up in the manure," he says. "The flies develop in that manure, and they just don't appear to develop as well on fescue pastures. But that does depend on the level of toxin in the forage."

Studies of this phenomenon, done in cooperation with C. Dayton Steelman

of the University of Arkansas, have also pinpointed breed differences in fly infestations, according to Brown.

"On bermudagrass pastures, we've noticed that if, say, an Angus has 270 flies on it, a Brahman might have only 50," he says. "And you get the benefits of crossbreeding there, too—the F1 crosses, the first-generation crossbred offspring of Brahman and Angus, might have only 140."

Matching Animals to the Environment

How the producer mixes breeds can be almost as important as which breeds are mixed, Brown says.

"Among our F1 crosses, calves from Angus sires and Brahman dams are as much as 25 pounds smaller at birth than calves from Brahman sires and Angus dams," he points out.

"Our first objective here at Booneville is to see whether breed differences in areas such as maternal capabilities hold true across forages," Brown says. "If the answer is no, then we want to see what we can do to better match cattle to their environment.

"I'm convinced there's a lot of potential for interaction. That's what it's all about—matching these animal resources with what we have to work with in the environment."

Environmental issues also occupy the front burner at the ARS Subtropical Agricultural Research Station headed at Brooksville, Florida, by Andrew C. Hammond.

"In this country, there are 50 or more breeds of beef cattle," notes Hammond. "Of the ones with some adaptation to a subtropical environment like we have in Florida, the vast majority are either Brahman or some sort of Brahman composite.

"Brahmans serve us well; they're the backbone of the cattle industry here in Florida. But with the Brahmans come problems of reproductive

ROB FLYNN

Various breeds of heifers are grouped together at ARS' Brooksville, Florida, station to study the effects of pasture management and nutrition on their development. (K-4341-8)

efficiency, carcass quality, and to some extent, performance in the feedlot."

Hammond hopes to find the admirable tropical toughness of the Brahman in some other breed, perhaps a *Bos taurus,* that doesn't share the Brahman's problems.

"There are tropically adapted *Bos taurus* cattle in South and Central America and Africa," he notes. "One is the Romosinuano from Colombia. This is a criollo breed, brought over by the Spaniards; they've had some 300 to 400 years to adapt to the tropics."

Another promising *Bos taurus* is the Senepol breed, developed on the island of St. Croix at the turn of the century from a blend of the African N'Dama breed and the English Red Poll.

In cooperation with the University of Florida, the Brooksville lab acquired

Senepol semen in 1977 and Senepol females in 1982 to begin building a herd that in 1990 finally numbered 100 breeding-age females. [See *Agricultural Research*, September 1990, pp. 14-16.]

"Two years ago, we began crossing Hereford sires with Senepol dams, and Senepol sires with Hereford dams," Hammond says.

"When you crossbreed, you get performance that's above the average of the parents. We are collecting a second year's data now on these crosses, and we want to get at least 3.

"But this looks promising so far. I believe the Senepol will probably find their way into the cattle industry in the same way that the Brahman did—some as purebreds, but mostly for what they contribute to crossbreeding programs. But we need to know exactly what they will contribute."

Although the Senepol is a *Bos taurus* rather than a *Bos indicus*, the breed has much in common with the Brahman, Hammond notes.

"The purebred Senepol cow's reproductive performance at Brooksville is very much like the Brahman's," he says. "But maybe that's how these animals survive hot climates—by not investing their body stores in having a calf every year when nutrition is limited."

On the plus side, Senepol are more docile than Brahmans, Hammond says. Still to come: evaluations of the Senepol carcass for qualities such as tenderness.

With the Senepol research well on its way, the Brooksville team is now turning a greater share of its attention to the Romosinuano breed from Colombia.

As part of a joint project with the University of Missouri at Columbia, the University of Florida, and Jim Griffin of Reproductive Technology International in Plant City, Florida, ARS researchers in 1990 obtained Romosinuano embryos imported from Costa Rica. Half of those embryos were implanted in Brahman cows, half in Angus, and the first calf crop is now on the ground at Brooksville and available for study.

"But this is a long process," Hammond warns. "Look at where we are with the Senepol, just now able to look at reciprocal crosses, and we've had Senepol females here since 1982. There's plenty of work still to do."

—By **Sandy Miller Hays,** ARS.

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Mapping a Route to Better Beef

Rand McNally mapped America, noting the highways, byways, and everywhere in between. Now, finding the way from one city to another is as simple as checking a map.

Scientists with the Agricultural Research Service want to make cattle selection just as easy for ranchers. Researchers at the agency's Roman L. Hruska U.S. Meat Animal Research Center (MARC) will spend the next few years studying cattle's overall genetic makeup—called the genome—as part of a major livestock gene-mapping program.

The goal of the $2 million project at the Clay Center, Nebraska, facility is to identify genes at evenly spaced intervals along each of the 29 chromosomes that make up the bovine genome.

"It will be similar to the highway markers you see along the side of the road," says Roger T. Stone, a physiologist at MARC. "They will give us an idea of where we are, but we won't know what's in between."

Those markers could represent various production traits that are of economic importance to farmers and ranchers. They will also help researchers identify the genetic matter between the markers.

"By identifying genes or groups of genes that control production traits, the cattle industry will be able to produce beef for specific markets," says Dan Laster, director of MARC.

"This will also allow us to identify groups of genes responsible for resistance to diseases and parasites," adds Roger J. Gerrits, ARS National Program Leader for Animal Production.

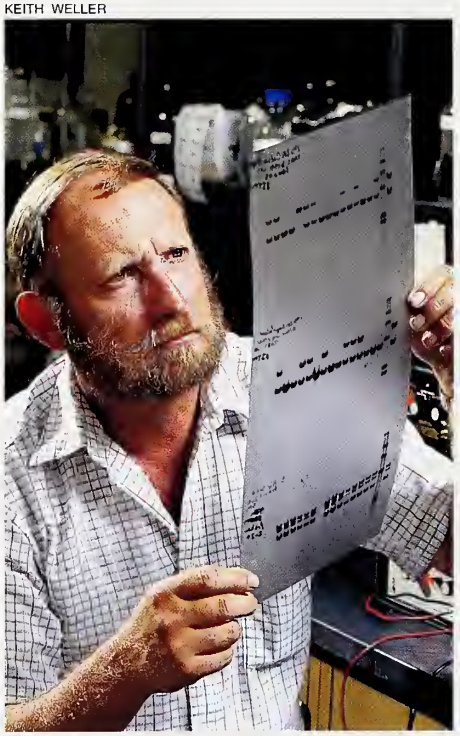
"The gene mapping and evaluation program will accelerate the rate of genetic progress and will be essential to improve the quality and safety of food for human diets, as well as competitiveness of U.S. agriculture."

Eight scientists and support personnel are working on the project at MARC. Craig Beattie, a molecular biologist from the University of Illinois-Chicago, has been hired to head the project.

"This is truly a new era of science," says Gerrits. "Research with the bovine genome will accelerate our ability to improve reproduction, meat quality, disease resistance, and the metabolism of muscle and fat."

Most of the work will require the use of DNA probes to identify the gene markers. One class of probes will bind to a specific form of a gene known as an allele. For example, a probe with the genetic makeup for black coat color will seek out only that actual gene and not the alternative gene for red coat color.

KEITH WELLER



Using a DNA probe, animal physiologist Roger Stone examines film showing genotypes of specific animals. (K-4287-10)

Once marker genes have been identified, the maps will become an important basis for developing breeding programs. Breeders and researchers now rely heavily on statistical methods to identify animals of a specific genetic makeup.

"The maps are a place to start, not a place to reach," says Laster.

Knowing the genetic background of a calf could help identify which animals are likely to make the most efficient use of available feeds and produce the most tender meat. Gene maps could also assist producers in selecting animals that are best suited to a particular environment.

"Current technology enables scientists to splice, clone, and insert genes to change the genetic makeup of an animal," says Gerrits. "Mapping the bovine genome will also allow us to use these available technologies to improve livestock production."

Although the project is in its initial phases, researchers will not be starting from scratch. Scientists expect to make use of existing maps of the human and mouse genomes to build on current livestock gene maps, which are comparatively sparse.

The base sequences—chemical components—of cattle genes are the same as in humans about 80 percent of the time. Probes made from human DNA could bind to the equivalent bovine genes, speeding the mapping process. Bovine probes may also assist the human genome mapping efforts.

"About 200 bovine genes have already been identified, and researchers know where some of these genes are likely to be located on the different chromosomes," says Larry V. Cundiff, leader of the Genetics and Breeding Research Unit at MARC.

Roger Stone has isolated and sequenced seven genes related to disease resistance in cattle. Known as the bovine major histocompatibility complex, or MHC, the genes are similar in structure and genetic diversity to those of the human and other animal species.

The studies by Stone and former ARS colleague Noelle Muggli-Cockett

By taking a gene-by-gene look at a steer's make-up, scientists are working to bring ideal cattle to the marketplace.

began in 1985 and used the human genome map and DNA probes.

The goal of the disease resistance portion of the genome research is to improve the overall health of livestock without compromising desirable production traits like growth, reproduction, or meat quality.

However, as researchers attempt to use gene maps and related technology to improve production, special attention should be paid to the potential impact of the selection process on disease resistance.

"A producer may be unknowingly selecting animals with decreased disease resistance when selecting for increased production," says E. Travis Littledike, leader of the Animal Health Systems Research Unit at MARC.

"Disease can become a major limiting factor determining herd size. The larger the herd, the more stringent the requirements for sanitation, hygiene, and effective vaccination programs become," Littledike adds.

To zero in on genes related to disease resistance, researchers will first have to separate environmental effects from immune effects and determine the physical attributes that can contribute to diseases such as hoof anatomy to foot rot. Then, genetic resistance can be attacked from two angles—immune response and physiological factors.

Mapping may also assist researchers in their efforts to fight diseases such as bovine viral diarrhea, which cost producers millions of dollars each year.

For instance, identification of the receptor gene locations in the bovine genome that code for the BVD virus receptors on cell surfaces would promote studies of how these genes are regulated. If probes were available for these genes, then selection of cattle resistant to BVD may be possible.

"Genetic improvement of disease resistance is going to be a long, slow process," Littledike says. "It's not the answer in the short run, but in the long run, it will be worth the effort."

In the meantime, management practices, especially hygiene, will continue to play a key role in minimizing the incidence of disease.

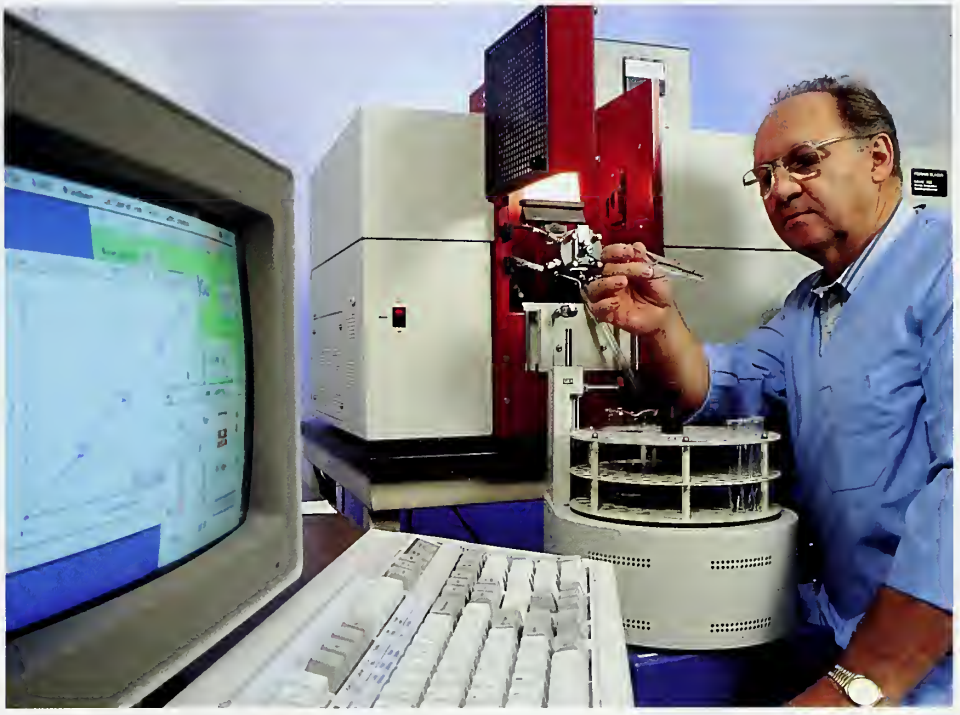
Scientists anticipate the genome mapping project and other related research will provide considerable amounts of useful information and technology within 10 to 15 years.

Laster expects the research to make tremendous contributions to the livestock industry. "Once the genes are mapped, we'll be better able to move animal germplasm from one country to another," he says.

Not only is the information expected to be useful to cattle producers and related industry, but it may also be of value to researchers mapping the genome of plants and other animals. Conversely, ongoing research to map those genomes may assist bovine mappers in their efforts.

Gerrits says one goal of the genome mapping program is to put all of the information into a database that can be used by scientists at federal, state, and private research facilities. An international database to link scientists throughout the world may also be developed in the future.—By **Marcie Gerrietts,** ARS.

KEITH WELLER



Veterinary scientist Travis Littledike analyzes the effect of trace minerals on animal resistance to disease. (K-4287-5)

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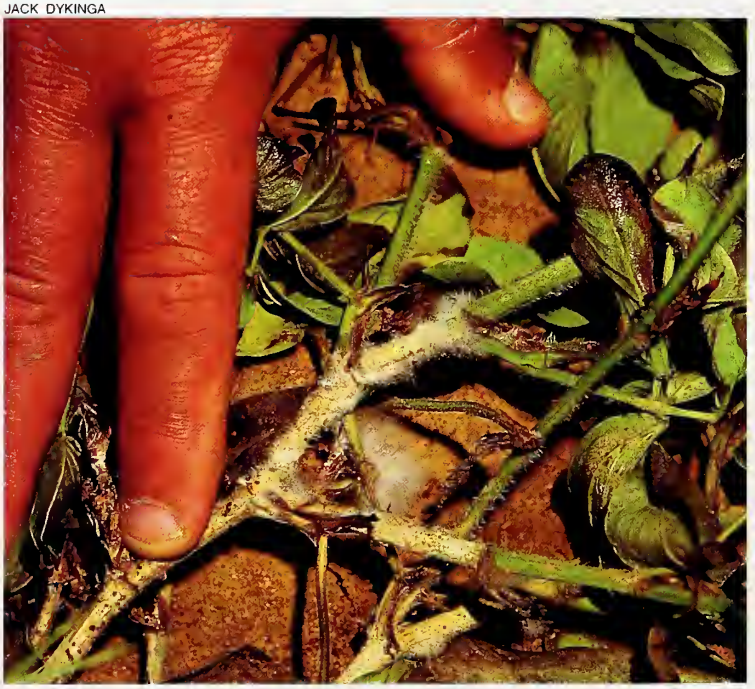
Confronting a New Fungal Nightmare

JACK DYKINGA



Peanut stems showing typical symptoms of *Sclerotinia* infection including fluffy white mycelia, black sclerotial bodies, and tan lesions. (K-4291-6) Background photo: Spanish, Virginia, and runner peanuts. (K-4297-4)

On an August day in Virginia in 1971, peanut stems near moist soil were discovered to be covered with what looked like cotton.

The plants soon began to wilt and brown. A few days later, the cotton, which was really the vegetative stage of a fungus, gave way to small black sclerotia—bodies that looked like mouse droppings.

What U.S. peanut farmers were seeing for the first time in 1971 was sclerotinia blight, destined to become their worst nightmare. It took two decades, but the blight caused by the soilborne fungus *Sclerotinia minor* has become a major problem—not only in Virginia but in the Southern Plains a thousand miles away where one-fifth of the nation's 1.6-million-acre peanut crop is grown. Today the fungus also attacks lettuce growing in New Jersey, New York, and California.

In recent years, about a third of Oklahoma's 105,000 peanut acres and more than 20,000 acres in Texas have been infested by *Sclerotinia.* Some fields have suffered yield reductions of as much as 25 percent, says Hassan A. Melouk, an Agricultural Research Service plant pathologist at Stillwater, Oklahoma.

There are at least a half dozen possible ways in which Sclerotinia blight spreads; the planting of infected seed is only one. The pathogen, which survives in soil as long as 7 years, also lurks in dead plant material, live weed hosts, farm equipment, ruminants, and even living birds.

Sclerotinia blight is surely frustrating to Oklahoma farmers who have been permitted, up till now, to use only one fungicide. Each of two or three applications in a growing season costs nearly $40 per acre.

Despite governmental programs aimed at supply-demand stability, consumers may feel the financial pinch of increased peanut prices in years when the disease contributes to a nationwide drop in yields.

But there is some relief in sight from a new seed treatment that will help in reducing the disease's spread.

JACK DYKINGA

Plant pathologist Hassan Melouk examines pod sets of healthy, freshly dug runner (left) and Spanish (right) peanut plants. (K-4293-11)

The treatment consists of a combination of three fungicides that have been registered for other purposes. They are captan, pentacloronitro-benzene, and thiophanate-methyl.

In laboratory studies, the combination can cut the incidence of seed infection by 99.6 percent. Other seed treatments reduced infection by less than 80 percent.

While this chemical combination may help slow the disease spread, the importance of other measures, such as weed control, remains.

What's needed, he believes, is an integrated approach—one that combines disease-resistant varieties, chemicals, and possibly, biological controls.

It should be noted that there may be state and local regulations restricting the use of certain fungicides. Also, because registrations of fungicides are under constant review by the U.S. Environmental Protection Agency, growers should consult their county agricultural agent or state extension specialist to be sure the intended use is still registered.

Spanish peanuts, the small-seeded, round peanuts that are popular cocktail-party fare, differ in more ways than just seed size from runner peanuts.

It's been found that plants bearing Spanish peanuts are generally less susceptible to the Sclerotinia fungus than are the runner types. An especially resistant Spanish variety, Tamspan 90, has been developed and released by Melouk and researchers at Texas A&M University at College Station.

In 3 years of tests in nine Texas counties, Tamspan 90 produced peanuts worth 10.5 percent more than yields from an old standby variety, Starr. Where the Sclerotinia fungus was most prevalent, the new variety produced peanuts with a 48 percent higher value than that of Starr.

In 1990, companies began to increase seeds of Tamspan 90 for peanut producers to plant for the first time this year. A seed producer in west-central Oklahoma's Caddo County, whose seed yields normally range around 3,000 pounds per acre, says Tamspan 90 yielded more than 5,000 pounds per acre in 1990—his best crop in 20 years.

The first resistant varieties of runner-type peanuts may debut soon after the resistant Spanish peanuts; researchers of

JACK DYKINGA

Seed peanuts. (K-4295-19)

ARS and Oklahoma State University, Stillwater, have joined in the search. "We've tested several cultivated lines that have looked promising the last couple of years," Melouk says.

Breaking the Cycle of Infection

Some infected peanut seeds appear to be less likely to transmit the fungus to the next generation, an observation that might pay off in terms of new breeding lines. Melouk and two graduate students are researching the mechanism by which the fungus moves from an infected seed to a germinating seedling.

Seed infection, which one cannot detect by simply looking at the seed, becomes evident after the fungus on a seed fragment has been placed, or plated, on a growth-promoting agar medium for 7 to 10 days. To cut the time involved, Melouk is working on an enzyme linked immunosorbent assay (ELISA) that may allow diagnosis of infection in 1 day.

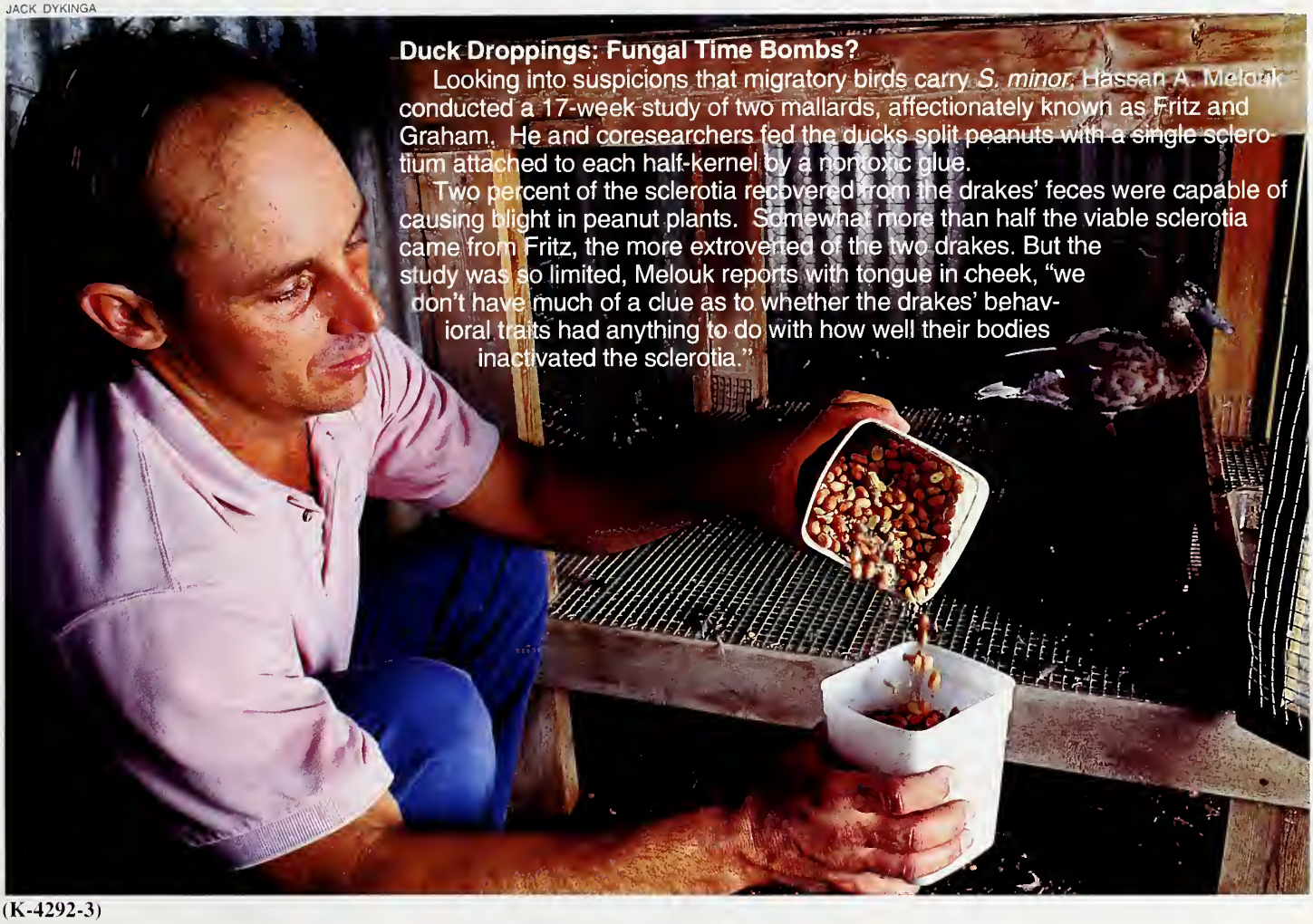
ELISA could speed his search for effective chemical and biological fungicides and for disease-resistant peanut breeding lines. In studies last year, Melouk and Carolyn Bowen, a graduate student, plated and looked at 26,000 seeds.

While no biological control system is yet commercially available for controlling *S. minor* in peanuts, Melouk and scientists at Oklahoma State, in cooperation with a major agribusiness company, are experimenting with a parasitic fungus, *Sporidesmium sclerotivorum.* In other studies on lettuce, ARS plant pathologist Peter B. Adams and his colleagues at Beltsville, Maryland, found that as little as 0.2 pounds of *S. sclerotivorum* per acre can compete with other microbes in the

JACK DYKINGA

Research assistant Carolyn Bowen evaluates the effectiveness of seed protectants against *Sclerotinia minor.* (K-4298-9)

JACK DYKINGA



Duck Droppings: Fungal Time Bombs?

Looking into suspicions that migratory birds carry *S. minor*, Hassan A. Melouk conducted a 17-week study of two mallards, affectionately known as Fritz and Graham. He and coresearchers fed the ducks split peanuts with a single sclerotium attached to each half-kernel by a nontoxic glue.

Two percent of the sclerotia recovered from the drakes' feces were capable of causing blight in peanut plants. Somewhat more than half the viable sclerotia came from Fritz, the more extroverted of the two drakes. But the study was so limited, Melouk reports with tongue in cheek, "we don't have much of a clue as to whether the drakes' behavioral traits had anything to do with how well their bodies inactivated the sclerotia."

(K-4292-3)

soil to reduce sclerotinia lettuce drop by more than 50 percent.

For now, Melouk sees resistant peanut varieties as a first line of defense against the disease, while he emphasizes the need to minimize presence of fungi in the soil. "With an average of one or two sclerotia per 100 grams of soil, 30 to 50 percent of peanut plants growing in that soil could become infected," he says.

No Easy Solutions

Rotating crops on infected soil will not, by itself, make the sclerotinia blight problem go away. Melouk and his colleagues have found that the fungus survives on weed hosts.

Recently they found viable sclerotia in the stems of both live and dead *Eclipta prostrata*, a plant in the sunflower family that often infests irrigated peanut fields. The weed may remain as a fungal reservoir on land that has been out of peanut production for several years.

Too much irrigation can also increase fungal infection. *S. minor* thrives in wet conditions when late summer heat begins to wane.

Here's another no-no for farmers. Don't move cattle from fields where they have grazed infected peanut crop residue to fields that aren't infected. That advice is based on studies conducted by Melouk and scientists of Oklahoma State's departments of plant pathology and animal science. The researchers fed a heifer sclerotia-infested oats and peanut hay for 10 days. Samples of feces and contents of the rumen collected 9 days after the feeding period contained an abundance of sclerotia, and 8 percent were capable of causing blight in peanut plants.—By **Ben Hardin,** ARS.

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Heed the Mummichog!

RICHARD NOWITZ

Developmental biologist George Gassner (background) and electrical engineer Michael Line discuss liver pathology in a mummichog in which a tumor has been found. (K-3826-1)

A beautiful small fish called the mummichog may be the environmental canary of the 1990's, at least for brackish bays or estuaries along the East Coast. Mummichogs develop tumors in the presence of carcinogenic water pollutants.

Carcinogens can come from industrial discharges, municipal waste, agriculture, and even natural sources.

"We're testing mummichogs as biological indicators of water quality, to be sure farm chemicals—fertilizers and pesticides—are used safely," says George Gassner, an ARS biologist in Beltsville, Maryland. "The mummichogs would be living sensors something like canaries used to detect toxic gases in mines at the turn of the century."

"But unlike exposing canaries to potentially fatal doses of gas, we're not threatening mummichog lives," Gassner adds.

In fact, Gassner's work with mummichogs very much resembles the care of people in the best of hospitals.

He removes fish from one of three saltwater aquaria and gently anesthetizes them and wraps them in plastic foam blankets that protect the fish from handling damage and drying.

The blanketed fish is carefully placed in a plastic tube and inserted into a nuclear magnetic resonance imaging scanner, a smaller version of the expensive MRI machines used in hospitals for noninvasive diagnoses in place of surgical biopsies.

The machine produces longitudinal views of the fish's interior; it "reads" magnetic energy related to a temporary magnetic rearrangement of hydrogen atoms when the scanner is switched on. The hydrogen atoms are in water molecules that are chiefly found in tissue. As in a hospital, Gassner uses the scanner to search for early signs of liver cancer.

Once the scanner is switched off, the atoms return to their original positions at different rates depending on the tissue type and whether it is healthy or diseased. By measuring these rates in fish livers, Gassner tries to identify tissue change not previously detectable and link that change to liver cancer developed later in life.

Gassner is interested in mummichogs as part of the ARS Environmental Chemistry Laboratory's search for biosensors—living plants, animals, or tissues used to give an early indication of the presence of dangerous pollutants.

Last year, Gassner discovered that extensive data had been collected on mummichogs from clean and creosote-contaminated sites in Virginia's Elizabeth River.

Through autopsies, Wolfgang K. Vogelbein, an aquatic animal pathologist at the Virginia Institute of Marine Science (VIMS) in Gloucester Point, Virginia, found a high prevalence of liver cancer, 35 percent, in mummichogs living in contaminated sites.

Gassner saw Vogelbein's data as a chance to prove that a fish like the mummichog is ideally suited for evaluation as a biosensor by MRI. "Here was a potential model biosensor with a database that would provide us with some background to step into," Gassner says.

In a cooperative effort with Vogelbein, Gassner has since used MRI to detect cancer in the fish without performing an autopsy.

Gassner says keeping the fish alive allows repeated measurements on the same fish. This is much more accurate than taking measurements at different stages from many different fish and using statistics from a group of fish, he says.

Now the scientists can follow the growth of tumors in live fish taken from polluted waters. They can also determine what, if any, environmental changes would reverse tumor formation.

"Individual fish are preserved unharmed for long-term study and can be returned to their natural habitat unchanged," Gassner says. As proof, he points to his favorite—a healthy 3-inch male mummichog swimming in an aquarium decorated with artificial rocks. This "patient" has logged a record 1 hour and 18 minutes in the scanner.

Gassner considers these fish good candidates as environmental sentinels because they are nonmigratory and abundant along the entire East Coast. He believes localized populations may therefore reflect the health of their immediate environment.

The fish are gray on top with white underbellies. The top and bottom fins and tail have silver sparkles on a black background. There are also sparkles elsewhere on the body.

They're also small and hardy, which makes them well suited to study.

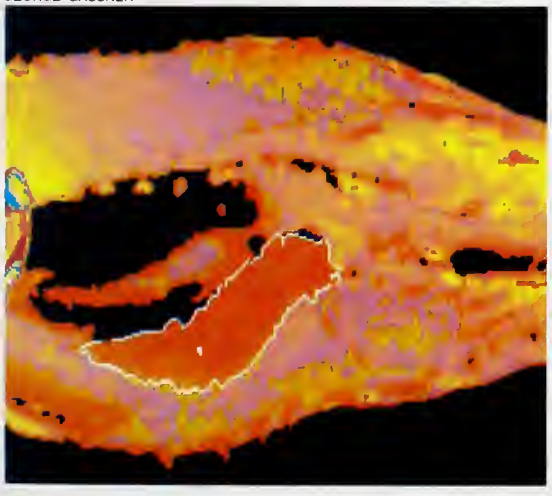
"Using this approach, environmental scientists and managers from federal, state, and local agencies can periodically monitor fish from various waterways, tag them for future studies, and return them to the rivers and bays unharmed," Gassner says.

He says the fish could be used to monitor estuaries worldwide. And fish aren't the only candidates for the MRI early warning system. Gassner is already considering crawfish, clams, and oysters and other shellfish.

C. Richard Amerman, ARS scientific planning adviser, says Gassner's work may contribute a valuable assessment tool to support the President's Water Quality Initiative, a national program begun in 1989 to ensure safe farming techniques.—By **Don Comis**, ARS.

George Gassner is at the USDA-ARS Environmental Chemistry Laboratory, BARC-West, 10300 Baltimore Ave., Beltsville, MD 20705-2350. Phone (301) 344-1030. ◆

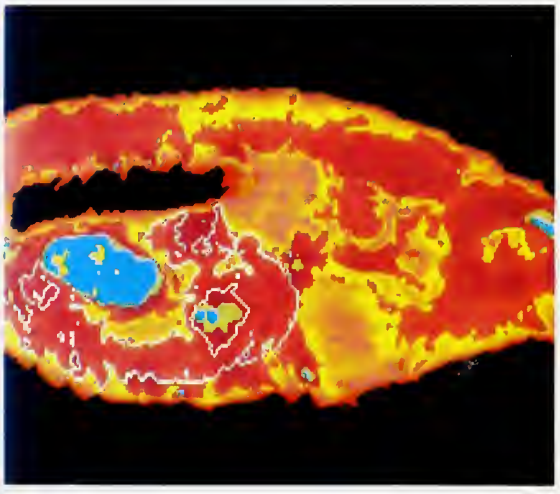
GEORGE GASSNER



Left:
Healthy mummichog liver outlined in white. The black area is the air bladder. (K-3826-1)

Right:
Mummichog liver showing fluid filled cyst (blue area). Lighter red area outlined in white is altered cellular foci and has the potential of forming additional tumors and becoming cancerous. (K-3226-18)

GEORGE GASSNER



Dwarf Daylily Debuts This Fall

A new dwarf daylily called Yellow Tinkerbell has been developed for use both as a perennial landscape border plant and a potted plant.

Its height—only 9 inches—is the result of research to further miniaturize the dwarf daylily. The most popular dwarf variety is actually quite large, reaching a flowering height of 28 inches.

The new dwarf is identical in all traits except size to one of the shortest daylilies, which is 16 inches tall.

Yellow Tinkerbell has bright yellow, 2-1/2 inch flowers on the 9-inch stems, bearing about 7 flowers per stem. It will flower in a 4-inch pot in just 8 weeks after less than 12 hours of light daily at temperatures as low as 41°F. The new plant has survived temperatures of -15°F and will be available to plant nurseries this fall for propagation.—By **Hank Becker,** ARS.

For further information, contact Robert J. Griesbach, USDA-ARS Florist and Nursery Crops Laboratory, 10300 Baltimore Ave., Beltsville, MD 20705-2350. Phone (301) 344-3574. ◆

Bovine Johnny Appleseed Revitalizes Ranges

Ranchers might someday use cattle, sheep, and goats to upgrade their rangeland—not by consuming undesirable plant species but by spreading the seeds of desirable plants.

Scientists are enlisting the unwitting cooperation of grazing steers to reseed land. They're fed gelatin capsules that contain seed of the plants scientists want to establish on poor-quality rangeland.

"Just like the kind of gelatin capsules we swallow, these dissolve in the stomach. In our case, medicine is released; in the steers' case, seed is released. Moving along with feed in the intestinal tract, the seed is excreted with manure 2 to 3 days later," says Agricultural Research Service plant geneticist Jerry R. Barrow.

Depending on seed size, the scientists filled the gelatin capsules with about 21,000 blue panicgrass seeds, 60,000 alkali sacaton seeds, or 800 fourwing saltbush seeds.

Barrow and range scientist Kris M. Havstad are learning how steers can be used to spread four forage plants native to the Southwest. In their study at the Jornada Experimental Range near Las Cruces, New Mexico, they discovered that about half of the fourwing saltbush, alkali sacaton, and blue panicgrass seed passed through the steers' unharmed. Another grass seed, sideoats grama, was completely digested.

"It would be hard to create a more ideal growing environment for seed—50 percent germinates. When it's planted this way, it's in the middle of manure droppings that contain moisture and all the nutrients plants need to start growing," says Havstad, who is also the research leader for the ARS Range Management Unit in Las Cruces.

Ranchers would feed capsules to their cattle, then lure them to an area that needed reseeding. The lure could be a temporary supply of water or a salt block that most livestock like to lick. Or they could feed cattle, then herd them to remote sections of their ranches so they arrive at areas that need upgrading up to 3 days later.

In this way, millions of acres of public and private rangeland could be improved by introducing more productive plants or by reseeding plants that have disappeared because of drought, past cultivation, or overgrazing.

"In many areas, we can't use mechanical seeding equipment because it might disturb threatened or endangered plants and animals. Other areas should not be tampered with because they are archaeologically important," says Havstad.

"Our cattle graze areas so rough and inaccessible that no conventional seeding equipment or technique could be used to improve the land," says Barrow.

Encouraged by the results, Havstad and Barrow say further research will determine whether goats and sheep can perform a planting service as well.—By **Dennis Senft**, ARS.

Jerry R. Barrow and Kris M. Havstad are at the USDA-ARS Range Management Unit, New Mexico State University, Las Cruces, NM 88003-0003. Phone (505) 646-4842. ◆

BRUCE FRITZ

Entomologist Robert Bartelt watches the Nitidulid beetle, *Carpophilus freemani,* respond to synthetic pheromone. Filter paper on right is a control which was not treated with pheromone. (K-4209-1)

Concocting the Ultimate Beetle-Juice

As alluring as the scents of fermenting fruits may be to dried fruit beetles, even more attractive are such scents when mixed with chemical attractants recently synthesized and patented by Agricultural Research Service scientists.

The "perfume" put into a custom-designed beetle trap could help farmers and warehouse managers gather the information they need to make decisions on pesticide applications.

Called aggregation pheromones, the chemical attractants synthesized by the research team are similar to those produced by a male beetle when he's found a food source. Coming from afar, many female and male beetles, sensing the pheromones, join into one big party to dine and mate, says entomologist Robert J. Bartelt of the National Center for Agricultural Utilization Research, Peoria, Illinois.

Besides synthesizing mimic pheromones of the dried fruit beetle, *Carpophilus hemipterus,* Bartelt and

entomologist Patrick F. Dowd patented ways to make similar attractants for two other insects that feed on a wide range of food commodities, the Freeman sap beetle, *C. freemani,* and the dusky sap beetle, *C. lugubris.*

Dowd says the pheromones are most effective when mixed with host plant volatiles such as odors of rotting fruit or similar volatiles from commercial sources.

The new inventions are being tested by scientists of the University of California, Riverside. Dried fruit beetles feed on many commodities, causing about $2.5 million damage to the California fig crop alone.

Besides damaging fruit through feeding and egg laying, the beetles may carry such crop-destroying diseases as smut, mold, and rot.

In some recent years, California fig growers have spent as much as $100,000 to control the beetles, which are an intermittent problem. If any company licenses the synthetic pheromone, fruit growers could better decide when or whether to spray their crops, says Bartelt.

Besides furnishing synthetic pheromones to California for testing, Bartelt has sent part of the "world's supply" from Peoria to entomologist Roger N. Williams of the Ohio Agricultural Research and Development Center (OARDC), Wooster.

OARDC scientists are cooperating in experiments around the world. For example, sap beetle numbers are being monitored in stored cocoa in Brazil. If all goes well, cocoa warehouse managers may sometimes be able to cut down on their use of the pesticide aluminum phosphide.

Although the traps seem most promising as a monitoring tool, says Bartelt, the pheromones may someday be combined with pesticides. The scientists have applied for a patent on making organophosphorus insecticides more effective for sap beetle control by mixing them with *Carpophilus* pheromones.—By **Ben Hardin,** ARS.

Robert J. Bartelt and Patrick F. Dowd are at the USDA-ARS National Center for Agricultural Utilization Research, 1815 N. University St., Peoria, IL 61604. Phone (309) 685-4011. ◆

Boosting Immunity in the Elderly

In study after study spanning decades, laboratory animals have maintained strong immune systems and lived substantially longer when raised on far fewer calories than they would normally eat. But why this works has been a mystery.

Now a clue as to how lifelong calorie restriction improves immune function in aging mice could point the way to improving older people's ability to fight infection and nip would-be cancers in the bud.

Researchers at ARS' Human Nutrition Research Center on Aging at Tufts found that mice who were raised on about 80 percent of their normal calorie intake synthesized significantly less prostaglandin E2 (PGE2). This hormone-like substance is known to suppress immune function, explains nutritional immunologist Simin Nikbin Meydani. So reducing the hormone helps to boost immune function.

Restricting food intake for extended periods is not practical for lean people. But Meydani says, "It is possible to reduce PGE2 levels through other dietary modifications, such as increasing vitamin E intake."

In fact, Meydani reported success in improving immune function in senior citizens with vitamin E supplements last year before she knew the results of the mouse study. (See *Agricultural Research,* Feb. 1989, pp. 12-13.)

She expects that a reduction in PGE2 is only part of the answer, but it's a beginning. Now, she says, researchers can design studies to see how individual nutrients known to alter PGE2 synthesis affect the immune system in elderly people.

The eyes of older people could also benefit from follow-up studies. Colleague Allen Taylor, who heads the Nutrition and Vision Research Laboratory at the center, found that calorie restriction significantly delayed cataracts in the test mice—which are from a strain that develops cataracts much as older people do. He says this is the first study that demonstrates the delay of senile-type cataracts in a living animal.—By **Judy McBride,** ARS.

Simin N. Meydani and Allen Taylor are at the USDA-ARS Human Nutrition Research Center on Aging at Tufts, 711 Washington Street, Boston, MA 02111. Phone (617) 556-3129 and 556-3155. ◆

Lakebed Sediment Cut by Farming Practices

Soil losses from farms around Mississippi's Moon Lake have dropped off significantly as farmers change to crops requiring less tillage. That has meant a cleaner, healthier life for the lake, a 4-square-mile body of water along the Mississippi River.

An ARS study of farm practices and 30 years of sediment deposit records documented how less intensive cropping practices can improve water quality.

Scientists found that from 1954 to 1965, about 70 percent of the lake had more than 1 inch of sediment deposited each year. But then farmers switched from cotton to soybeans and rice, which require less tillage.

Over the next 20 years, about 86 percent of the lake had less than an inch of sediment per year. This is one of the first long-term studies that proves how changing to less intensive cropping practices can greatly improve the water quality and aquatic habitat downstream.—By **Hank Becker,** ARS.

For further information, contact Charlie Cooper, USDA-ARS National Sedimentation Laboratory, P.O. Box 1157, Oxford, MS 38655. Phone (601) 232-2935. ◆

Correction

A couple of sharp-eyed ARS entomologists have pointed out that the moth shown in *Agricultural Research,* June 1991, page 19, is really a *Melipotis jucunda* Hübner—not related to the corn earworm moth.

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